Comet *e* 1906.

Date and G.M.T. 1906. d	h m s	Apparent R.A. h m s	Apparent Dec. ° ′ ″	Log. Parallax Factor. R.A.	Dec.
Aug. 28	12 24 28	22 45 5·33	+10 6 34·7	+7·909	+0·762
29	13 22 15	22 44 17·63	+10 2 20·7	+9·036	+0·766
Sept. 11	10 51 47	22 35 1·48	+ 8 54 23·6	−8·570	+0·773
25	10 24 13	22 28 7·13	+ 7 17 52·0	+8·248	+0·785
26	11 5 37	22 27 47·95	+ 7 10 40·3	+8·958	+0·788
27	10 26 39	22 27 31·62	+ 7 3 53·5	+8·549	+0·787
27	10 56 57	22 27 31·15	+ 7 3 44·1	+8·927	+0·789

Comet *g* 1906.

Nov. 17	13 5 42	9 47 58·07	+21 6 24·8	−9·578	+0·768
22	14 9 10	10 15 26·06	28 3 29·9	−9·558	+0·679
Dec. 10	13 50 55	12 25 54·32	50 4 6·1	−9·749	+0·562
12	13 55 23	12 42 49·47	51 43 23·4	−9·766	+0·553
21	12 59 28	13 57 37·79	56 51 2·3	−9·811	+0·692
1907. Jan. 17	11 49 51	16 31 15·30	60 46 4·7	−9·730	+0·826

Observations of Jupiter during the apparition of 1906–7.

By Rev. T. E. R. Phillips.

During the past apparition I was able to observe the planet on 106 occasions. The instrument used was a $9\frac{1}{4}$-inch equatorial reflector, the large mirror of which (originally by With) has been recently refigured by Mr Calver. Somewhat curiously—considering the exceedingly favourable position of the planet—atmospheric troubles proved unusually annoying, especially when observations were made before midnight. No doubt the somewhat low position of the instrument is partly accountable for this state of things, but there can be no question that the atmosphere was commonly much disturbed, and during the spring months the prevalence of cloud was almost abnormal. Owing to this latter cause observations had practically to be discontinued at the beginning of May.

The following are the particulars of the planet's position, etc. on the date of "opposition."

Date of "Opposition."	R. A. h m s	Dec. ° ′ ″	Equatorial Diameter. ″	Latitude of Centre of Disc. °
1906 Dec. 28	6 26 14	+23 12 50	47·8	+1·97

General Remarks on the Appearance of the Disc.

(1) *Surface Markings.*—The most notable change, as compared with the previous apparition, was the great development of the N. equatorial belt. It may be remembered that at the beginning of

1906 this belt was so feeble as to be little more than the N. edge of a slaty-blue shading, which at that time covered the N. part of the equatorial zone. The first indication of the great change that subsequently occurred was observed by Mr W. F. Denning, who in April found a very dark spot close to the S. edge of the N. temperate belt, and connected with the N. equatorial belt by a slanting streak. This spot seemed to be the centre of an eruption from which a large quantity of dark matter passed *via* the slanting streak into the N. equatorial belt. Unfortunately, the planet was then approaching conjunction with the Sun; but when observations were resumed in August, it was at once seen that a complete transformation had taken place. The N. equatorial belt then obviously exceeded the S. equatorial belt in breadth, and was distinguished by a remarkable series of alternate gaps or white rifts and very dark reddish streaks along its S. edge. These streaks were connected by delicate wisps with dark spots at the N. edge of the S. equatorial belt. Later in the apparition the N. equatorial belt was clearly seen to be triple, but the S. component was much the darkest of the three.

The great S. tropical disturbance was again an interesting feature of the disc. Its f. portion was still in conjunction with the red spot when observations were commenced in August, but the p. end, which had been very vague and ill-defined during the earlier part of the year, had regained all its former sharpness and clearness. The dark matter, as measured along the S. temperate belt, extended over nearly 60° of longitude at the commencement of the observations, but diminished to something like 47° by the end of the apparition. The length, as measured along the S. equatorial belt, was rather less. The p. and f. white spots were still conspicuous objects.

The old red spot was quite plainly seen on several occasions. It commonly presented the aspect of a faint elliptical grey shading which was lighter in the middle. The darkest portion was near the f. end, as has usually been the case in recent years, but in the moments of best seeing the dusky streak at its s.f. border appeared quite separated from the f. "shoulder" of the bay. There was also a wisp connecting the p. end of the spot with the S. temperate belt and the p. "shoulder." The well-known bay or hollow in which the red spot lies was again a well-defined object, with the exception that during the earlier part of the apparition the S. component of the S. equatorial belt was very narrow and very faint at and for some distance in front of the p. "shoulder."

(2) *Colour Changes.*—A conspicuous change of colour, as compared with the apparition of 1905–6, was exhibited by the N. equatorial belt. Distinctly bluish before the planet's conjunction with the Sun, it was decidedly red when observations were recommenced in August. A few months later the S. edge was still intensely red, almost brick-red in tone, but the central portion of the belt had faded to yellowish-red, and the N. edge to grey or even bluish-grey.

The S. equatorial belt, which during the previous apparition had been purplish, usually seemed wanting in distinctive colouring, but occasionally traces of purple or reddish-purple were seen, especially in the region following the f. "shoulder" of the red spot bay.

The whole of the disc from the N.N. temperate belt to the N. pole was commonly bluish-purple, whereas during the apparition of 1895–6 the N. polar regions had been reddish.

Rotation Periods.

My chief endeavour during the period covered by the observations was to secure as large a number as possible of eye-estimated transits of spots and other markings over the central meridian of the illuminated disc, with a view to determining the mean rotation period in different latitudes. About 1550 such transits were obtained, and on reducing them and charting the longitudes I found that about 90 objects had been sufficiently well observed to leave little doubt as to the identifications. The deduced mean values of the rotation periods of spots situated in the principal surface currents are given in the accompanying table.

Table of Rotation Periods.

Current.	No. of Spots observed.	Mean No. of Observations.	Mean No. of Rotations.	Rotation Period. h	m	s
South South Temperate Belt	1	11	171	9	55	10·9
Bright and dark spots at S. edge of South Temperate Belt	20	10	375	9	55	21·8
Great South Tropical Disturbance. *Preceding* white spot	1	23	639	9	55	22·9
Preceding end of dark matter (at S. Temp. belt)	1	32	644	9	55	22·6
Preceding end of dark matter (at S. Equat. belt)	1	21	434	9	55	23·5
Following end of dark matter (at S. Temp. belt)	1	26	610	9	55	21·1
Following end of dark matter (at S. Equat. belt)	1	16	355	9	55	21·3
Following white spot	1	21	478	9	55	21·3
Means for whole S. Tropical disturbance	6	23	527	9	55	22·1
Great Red Spot Hollow	1	34	589	9	55	42·2
White and dark South Equatorial spots	36	15·5	391	9	50	27·1
White and dark North Equatorial spots	18	14	310	9	50	41·8
Spots on North North Temperate belt	7	10	308	9	55	41·7
Spots within N. Polar shading	2	10	257	9	55	40·6

Remarks on the Rotation Periods and the Movements of Spots.

S.S. Temperate Belt.—The value here given is somewhat longer than that usually exhibited by spots situated in the great southern current. One or two transits were secured earlier in the apparition, which quite possibly belonged to the object observed, and which would make the period about normal (9^h 55^m 6^s ±). The identification is however uncertain, owing to a rather long gap in the observations, and the transits mentioned have consequently not been used in the reduction.

Spots at S. edge of South Temperate Belt.—The period of this current is also some two or three seconds longer than that usually found, but the number of spots observed is so large that there can be very little doubt as to the reality of the slight retardation indicated.

The Great Red Spot.—The rotation period of this object and of the hollow in which it lies has been notoriously variable during the last few years, especially about the times when the great S. tropical disturbance, which is situated in the same latitude and has a quicker motion, has been in conjunction with it. Conjunctions took place in 1902, 1904, and 1906, and on each occasion the effect of the dark material sweeping past the red spot has been to accelerate temporarily the latter's rotational velocity. This was especially marked last year. Thus in April 1906 the longitude of the red spot was about 29°, but when observations were recommenced in the second week in August it was found that the longitude had diminished to something like $15^\circ\!\cdot\!5$. So rapid a shift had not previously been observed in connection with the red spot. It is further noteworthy that the very marked rotational acceleration which the shift of longitude denotes had by that time entirely ceased, and was subsequently followed by a decided retardation. By the beginning of May 1907 the longitude of the red spot and hollow had increased to rather over 24°.

The Great S. Tropical Disturbance.—It will be remembered that Major Molesworth, as the result of certain computations, has suggested an interesting hypothesis as regards the manner of the passage of the S. tropical disturbance from the f. to the p. side of the red spot. This passage undoubtedly takes place *via* the S. temperate belt, but the special point in Major Molesworth's contention is that the apparent transference of matter is practically instantaneous. In other words, instead of the p. end of the disturbance occupying between two and three months in passing round the S. edge of the spot, he believes that almost immediately it comes up to the f. "shoulder" of the bay, dark matter appears above the p. "shoulder." It is as if the material of the S. temperate belt were incompressible, so that as soon as the dark substance of the great disturbance enters it, it displaces an equal quantity at the other end.

An opportunity of partially testing this hypothesis by actual

observations seemed to present itself at the time of the 1906 conjunction, but an unexpected difficulty arose through the extreme faintness and indefinite character of the dark matter which first appeared on the p. side of the red spot. Thus the p. end of the disturbance was observed to arrive at the f. "shoulder" ($\lambda = 47^\circ \cdot 5$ Syst. ii.) about Feb. 25, and the region above the p. "shoulder" ($\lambda = 10^\circ \pm$) was immediately watched. The expected dusky material, however, did not make its appearance, or at any rate it was not sufficiently intense to be observed. But later on, in the early part of April, it became obvious that the S. tropical zone above and in front of the p. "shoulder" had lost something of its white appearance, though it was not as yet possible to feel sure of the existence there of the stream of dark matter. By the middle of the month, however, all doubt had vanished, and the p. end of the disturbance was clearly discerned in about $\lambda\, 355^\circ$. Now, working backwards from the observed rate of motion during the apparition just closed, it appears that this must have been just about the longitude at the middle of April; and further, that the p. end of the disturbance, supposing it to have been moving at a uniform rate, must have been at the p. "shoulder" about March 11.

According to this computation, then, the p. end traversed the distance between the two "shoulders" of the bay—some 37°—in only fourteen days, instead of occupying nearly three months in the transit!

An investigation of the motion of the f. end of the disturbance gives a closely similar result. As above mentioned, the red spot hollow exhibited a quite abnormally large shift in longitude during the time of the planet's invisibility; and at the resumption of observations the longitude of the f. "shoulder" was only about 34°, and that of the p. "shoulder" about 357°. On the occasion of my first observation in the new apparition (1907 August 10) the dusky wisp connecting the end of the red spot with the f. "shoulder" was so dark and broad as to give the impression that it was in reality the f. end of the great S. tropical disturbance just arriving at the f. "shoulder" of the bay, and an entry to this effect was made in my observation-book. This surmise is confirmed by the fact that, assuming a constant rate of motion, the f. end of the disturbance was due in this longitude about August 7, only a very few days before the observation above mentioned. Now, the first few observations I was able to secure of the f. end of the disturbance after its appearance on the p. side of the red spot make it clear that Aug. 22 was about the date of its conjunction with the p. "shoulder." This means that the f. end of the disturbance traversed the length of the red spot bay between approximately August 10 and 22, instead of occupying nearly three months in the process.

On the whole, therefore, it seems that my observations confirm the main point of Major Molesworth's theory, though indicating an interval of about two weeks as needed for the apparent transference of the dark matter from the f. to the p. side of the red spot.

Equatorial Spots.—The motion of both S. and N. equatorial spots varied considerably during the course of the apparition, a decided acceleration of S. equatorial spots between longitudes 0° and 210° ± (System i.), and of N. equatorial spots in almost all longitudes, setting in towards the end of January. There was a very large difference of rate—amounting to over 14 seconds per rotation—between the two portions of the equatorial current.

Description of an Equatorial Reflecting Telescope driven by a Hydraulic Ram. By T. E. Heath.

The drawing shows the optical axis of the telescope pointing to the pole.

A, reflecting telescope ($8\frac{1}{2}''$ mirror) in square teak tube.

B, cast-iron right ascension circle 21″ dia., having a groove formed round periphery.

C C, cast-iron A frames bolted to R.A. circle, carrying declination axis, and allowing telescope to be set at any declination from 40° S. to 90° N.

D, cast-iron circle, carrying steel balls upon which the R.A. circle revolves.

E, cast-iron base-plate, to which D is bolted.

F, declination axis.

G, rope, which fits bottom of the groove in R.A. circle and is kept taut by a tension pulley carried by a lever H which is pulled by a spiral spring I. The rope passes over guide pulleys K, and one end of it is attached to the bottom of a hollow brass hydraulic piston L and the other end to a cross-bar M, which is supported at a sufficient height above the piston L by the pillars N. O is a brass hydraulic cylinder, 8″ dia. and 10″ high. (The piston L has a cup-leather below it.) The supply of liquid to the cylinder is regulated by a valve P (which is one of those sold to regulate the supply of oxygen from a cylinder). The valve is operated by a lever Q, to one end of which is attached a cord R and to the other end a cord S. The cords R and S are led over suitable guides to either end of a bar T, which hangs from the roof of the observatory, conveniently near to the observer.

The telescope is balanced by about 10 lbs. of lead attached to the lower end of the tube, so that it will stay at whatever declination it is set, and so that the force required to move it in R.A. is everywhere approximately the same.

I find that if the rope G be so large that it covers the bottom of the groove in the R.A. circle, but not so great that it grips the sides, and the spiral spring be an ordinary "door pull," then the friction will not prevent the observer easily setting the telescope on any required star, but will be sufficient when he lets go the telescope to cause the R.A. circle to revolve.